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LEVEL II

12

ENGINEERING AND DEVELOPMENT PROGRAM PLAN

ADVANCED INTEGRATED FLIGHT SYSTEMS (AIFS)

MAY 1978

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U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Systems Research & Development Service
Washington, D.C. 20590

APPROVED: ______________________________
Director, Systems Research and Development Service, ARD-1

APPROVED: ______________________________ MAY 18 1978
Associate Administrator for Engineering and Development, AED-1

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16. Abstract

Airplane development in the past has been spawned by the desire for improved performance usually through more efficient aerodynamic designs or propulsion systems. However, most recent advances have been systems oriented. One of the most noteworthy advances has been the development of the command and control electronic devices which are utilized in the application of active controls and other advanced aeronautical concepts. These advanced concepts offer improved aircraft performance through increased energy efficiency. NASA's Aircraft Energy Efficiency (ACEE) Program has stimulated active and aggressive development of these concepts and will hasten their introduction into the civil transport fleet. It appears that active controls and digital flight control and avionics will significantly impact transport aircraft technology, and therefore, FAA must examine the impact of these advances on airworthiness criteria. To comply with its charged responsibilities, the FAA must stay abreast of technology advancements and establish the necessary safety standards. In the areas of active controls technology and digital flight control and avionics, a technology program entitled "Advanced Integrated Flight Systems" (AIFS) has been established to support this responsibility. The AIFS Technology Program will provide for the acquisition or development of the generic data base from which the Flight Standards Service may develop airworthiness criteria and compliance procedures for aircraft and equipment evolving from the application of advanced integrated flight systems technology.

17. Key Words
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The contents of this Plan reflect the views of the Flight Standards Service, Office of Systems Engineering Management, Systems Research and Development Service, Federal Aviation Administration, who are responsible for the facts and the accuracy of the information presented herein. The contents do not necessarily reflect the official views or policy of the Department of Transportation. This Plan does not constitute a standard, specification, or regulation.

Subsequent revisions, amendments, or adjustments to this Technical Program Plan may be initiated, based on project additions (or deletions), major funding level changes, and schedule revisions.

ACKNOWLEDGEMENT

This document was developed by the FAA Advanced Integrated Flight Systems (AIFS) Planning Group members as follows:

Chairman

Edward M. Boothe, ARD-530

Flight Standards Service, Engineering and Manufacturing Division

R. Allen	Airframe Branch	AFS-120
R. Huhn	Systems Branch	AFS-130
R. Nugent	Propulsion Branch	AFS-140
R. Ford	Flight Test Branch	AFS-160

Flight Standards Service, Air Carrier Division

J. Flavin	Avionics Staff	AFS-206

Flight Standards Service, General Aviation Division

M. Sacrey	General Aviation Operations Branch	AFS-824

Office of Systems Engineering Management

H. Verstynen	Advanced Concepts Staff	AEM-20

Systems Research and Development Service, Aircraft Safety and Noise Abatement Division

E. Boothe	Aircraft Flight Safety Branch	ARD-530
L. Carpenter	Aircraft Flight Safety Branch	ARD-530
J. Reed	Aircraft Flight Safety Branch	ARD-530

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CAVEAT

This program, in order to cover the total technology of advanced digital flight control and avionics, active controls, etc., has utilized to the maximum extent possible joint programming, monitoring of other agency and industry work, and where necessary, independent contract efforts. This Plan addresses all these efforts as appropriate and, in each case, identifies the organization doing and funding the work to give the reader the proper perspective of the total aviation community effort.

EXECUTIVE SUMMARY

This Plan sets forth the program elements, schedules, and funding levels needed to meet certain Federal Aviation Administration (FAA) obligations in preparing for certification of the next and future generation of transport aircraft which will incorporate advanced digital flight control and avionic, and active control systems for primary flight control and other functions.

The FAA will be confronted, in the near future, with the task of revising and modernizing its airworthiness standards and certification procedures to maintain flight safety for transport aircraft utilizing advanced systems technology. Present standards address certification from the concept of separate engineering disciplines. Aircraft incorporating advanced digital flight controls and avionics, active controls and related concepts will be dependent on the interaction of the pilot, the control and augmentation system, the propulsion system, and the structure as a total integrated system. For the FAA to meet its responsibilities, concentrated effort must be initiated to acquire generic data and information to assure that airworthiness standards and certification procedures keep pace with the technology.

The energy shortage of the early 1970's showed the need for improved aircraft performance and efficiency. In January 1975, the United States Senate Committee on Aeronautical and Space Sciences suggested that the National Aeronautics and Space Administration (NASA), ". . . consider establishing a clearly defined goal of demonstrating the technology necessary to make possible a new generation of fuel-efficient aircraft." In response, NASA established a task force of Government scientists and engineers who served as a basis for the establishment of the NASA Aircraft Energy Efficiency (ACEE) Program. The ACEE Program promotes advanced systems technology as one means of improving energy efficiency.

Simultaneous to NASA efforts, the FAA was completing a staff study to determine active control technology (ACT). Also, a joint NASA and FAA workshop was undertaken to investigate methods for certification of digital flight control and avionic systems. These activities indicated that the introduction of derivative aircraft using advanced systems are expected in the 1981 to 1983 time frame. A new generation or more advanced aircraft which may be critically dependent upon systems concepts is expected about 1985 or later.

Anticipating an impact on airworthiness standards and certification procedures, the FAA Flight Standards Service (AFS), Office of Systems Engineering Management (AEM), and Systems Research and Development Service (ARD) established the Advanced Integrated Flight Systems (AIFS) Technology Program in December 1976.

Program Objectives

The FAA AIFS Technology Program objectives are to:

1. Evaluate and assess advancing technology for impact on FAA.

2. Support the development of airworthiness standards and certification procedures.

3. Disseminate technical information within FAA.

CRITICAL ISSUES which relate to the airworthiness considerations and which must be addressed by the FAA are:

1. Systems failure modes and failure effects.

2. Hardware and software reliability, including verification and validation.

3. Lightning, electromagnetic, and other transient effects.

4. Aircraft flight characteristics and performance.

5. Structural aspects of active controls.

TECHNICAL APPROACH of this program consists in a large part to monitor activities of interest at NASA Centers (Langley, Ames, Lewis, and Dryden), Department of Defense (DOD) laboratories, and industry. Where necessary, FAA funded contracts or interagency agreements will be used to satisfy specific FAA requirements.

The AIFS Technology Program includes the following major project elements:

1. Airworthiness Standards and Certification Procedures.

2. Digital Flight Control and Avionics.

3. Flight Characteristics and Performance.

4. Structures.

5. Propulsion Control.

6. Crew.

END ITEM PRODUCTS for the above six elements consist of the acquisition of appropriate generic information, and the development of recommendations from which the Flight Standards Service may develop appropriate certification procedures or form a basis for revised airworthiness standards.

INTERFACING PROGRAMS are primarily NASA ACEE/Energy Efficient Transport (EET) programs at Langley Research Center (LaRC) and those conducted by the Electronics Directorate at LaRC addressing advanced digital systems technology. The Ames Research Center (ARC) is supporting program elements in digital flight controls

and avionics systems using their simulation capabilities. It is expected that related programs at the NASA-Lewis Research Center (LeRC) and Dryden Flight Research Center (DFRC) will also provide data and information. The Air Force Flight Dynamics Laboratory (AFFDL) and Aeronautical Systems Division (ASD) may be additional interfaces. AFFDL has requested that FAA participate in various programs as military results may be applicable to civil transport aircraft.

FUNDING levels shown below are in 1977 dollars and are the totals of two separate program efforts:

1. Interagency Agreements.

2. FAA Contracts.

Through utilization of these two approaches, with the first intended as a stimulus to NASA to undertake FAA needed work, the stated objectives can be accomplished.

77	78	79	80	81	82	83	84	85	86
270	395	415	700	630	650	850	250	85	85

GRAND TOTAL: $4,330

Detailed estimates of in-house program resources can be found in Section 7.0 by Fiscal Years from 1977 through 1986. The total program resource requirements (dollars x 1,000) are shown below:

77	78	79	80	81	82	83	84	85	86
120	120	160	160	160	160	160	160	120	120

GRAND TOTAL: $1,440

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1. INTRODUCTION/BACKGROUND

Past incentives for advanced aircraft development have carried the promise of increased performance. The use of new technologies and incentives to undertake derivative and new aircraft development today must also promise improved performance. Instead of "higher" and "faster," however, improved performance is couched more in terms of greater efficiency, reduced fuel consumption, and maintaining or increasing return on investment. The technology which allows improved performance in this context is largely systems-oriented.

Much of the progress in aeronautics in the last two decades has been systems-oriented. Application of modern systems concepts and capabilities to achieve increased overall performance and efficiency has been stimulated by the energy shortage of the early 1970's. In January 1975, the United States Senate Committee on Aeronautical and Space Sciences suggested that the Administration of NASA, ". . . should consider establishing a clearly defined goal of demonstrating the technology necessary to make possible a new generation of fuel-efficient aircraft by a stated date. Such aircraft would have the same general operating characteristics as at present, would meet safety and environmental requirements, would be similar in cost, could be flying in the 1980's, and would have a large improvement in fuel efficiency." In response to that request, NASA established a task force which was convened in February 1975 and consisted of Government scientists and engineers from NASA, Department of Transportation (DOT), DOT/FAA, and DOD.

The task force obtained recommendations from various sources, which included specific Government research centers and laboratories, and industry engine, airframe, and electronic manufacturers. An analysis of Government and industry recommendations was performed, and a task force report (Reference 1) was publicly released. The task force report served as a basis for the establishment of the NASA ACEE Program which includes participation by both industry and other Government agencies.

Simultaneous to NASA efforts, the FAA was completing a staff study on the background of ACT and control configured vehicles (CCV). The resultant letter report (Reference 2) provides a history of the subject, describes recent related projects, and summarizes some possible regulatory implications of these new and advanced technological concepts. In addition, a joint NASA and FAA workshop (Reference 3) was undertaken to investigate methods for certification of digital flight controls and avionics systems.

Since implementation of these technological developments on transport aircraft will impact airworthiness standards and procedures for certification of derivative and new aircraft, the FAA AFS, AEM, and ARD established the AIFS Program in December 1976. The AIFS Program will investigate the airworthiness certification aspects of advanced digital flight control and avionic systems, active controls, and related

disciplines for derivative and new generation aircraft. The purpose of active controls is to reduce structural design loads, augment flutter design margins, augment the stability of airframes with reduced static stability, and match propulsive systems precisely to the airframe and operational conditions. Digital electronics make the use of active controls feasible. Their use, however, results in the likelihood that the stability, performance, and flying qualities of future aircraft will be critically affected.

The active control functions which may be applied in the near term, about 1980 to 1983, include:

- Maneuver Load Control (MLC).
- Gust Load Alleviation (GLA).
- Elastic Mode Suppression (EMS).
- Envelope Limiting (EL).
- Relaxed Static Stability (RSS).

Each of these functions is defined and described in Reference 2. Far-term technologies for 1985 and later application in transport aircraft include flight critical application of these listed above plus:

- All digital fly-by-wire controls.
- Active Flutter Mode Suppression systems (FMS).

Advanced systems employed for maximum benefit implies flight critical application in aircraft designed to be totally dependent upon electronically commanded flight control systems as opposed to previous and current stability augmentation systems that have improved but have not been the sole provider of stability. Total failure in such systems must be extremely improbable because it would result in catastrophe. Standards and procedures will be developed to assure the aircraft has been subjected to any failure condition not considered extremely improbable.

Based on current information, derivative aircraft are expected to be introduced in the 1981 to 1983 time frame with more advanced aircraft appearing in the 1985 to 1988 period. The introduction of new technologies in this evolutionary manner, with the more advanced long-term technology aircraft using concepts proved in non-flight critical derivative aircraft of near-term application, implies a two phase AIFS Technology Program. The Phase I results will form a basis for Phase II which will address the flight critical AIFS concepts. The content of the two phases is shown in Figures 1-1 and 1-2.

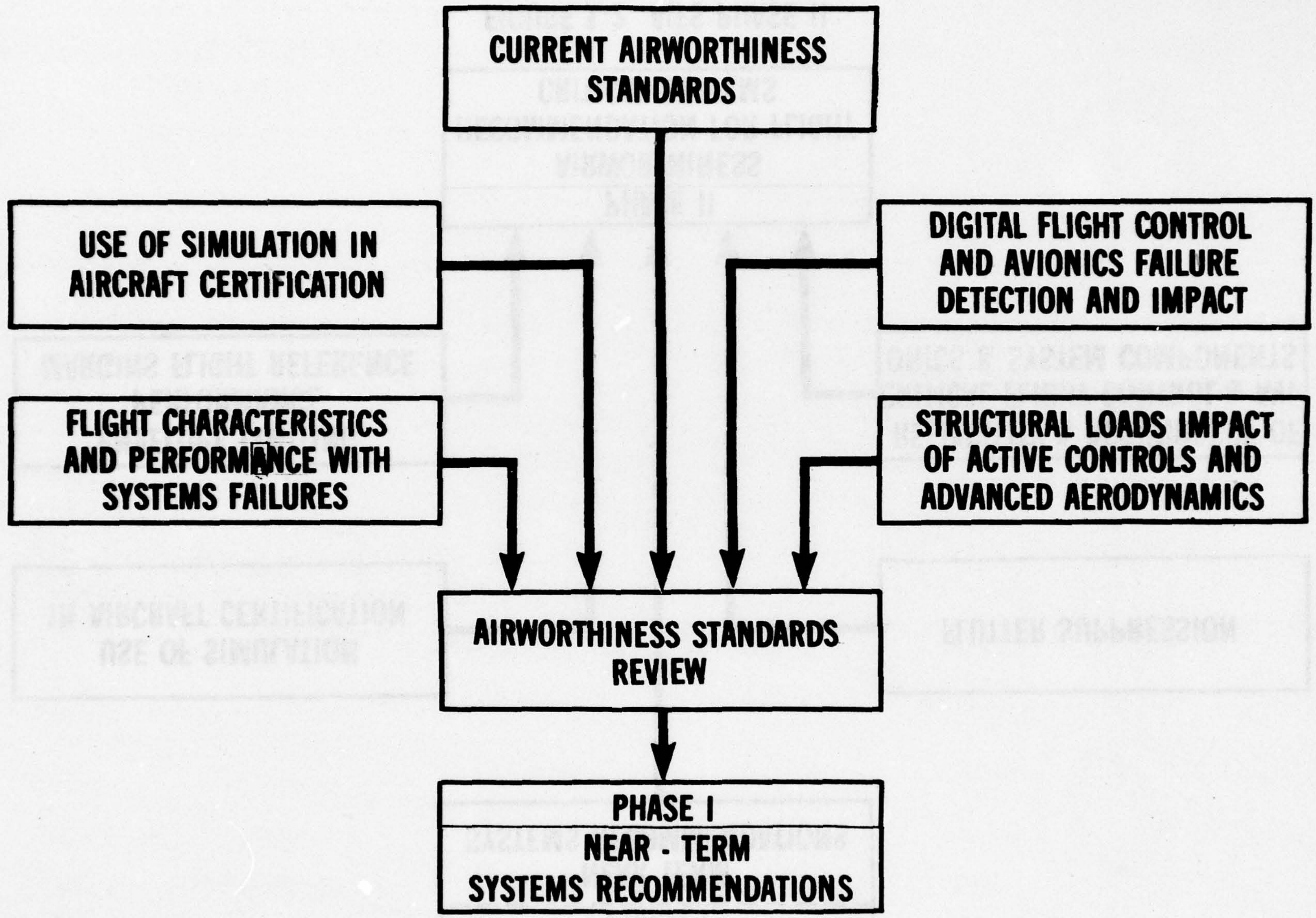


FIGURE 1-1 AIFS PHASE I

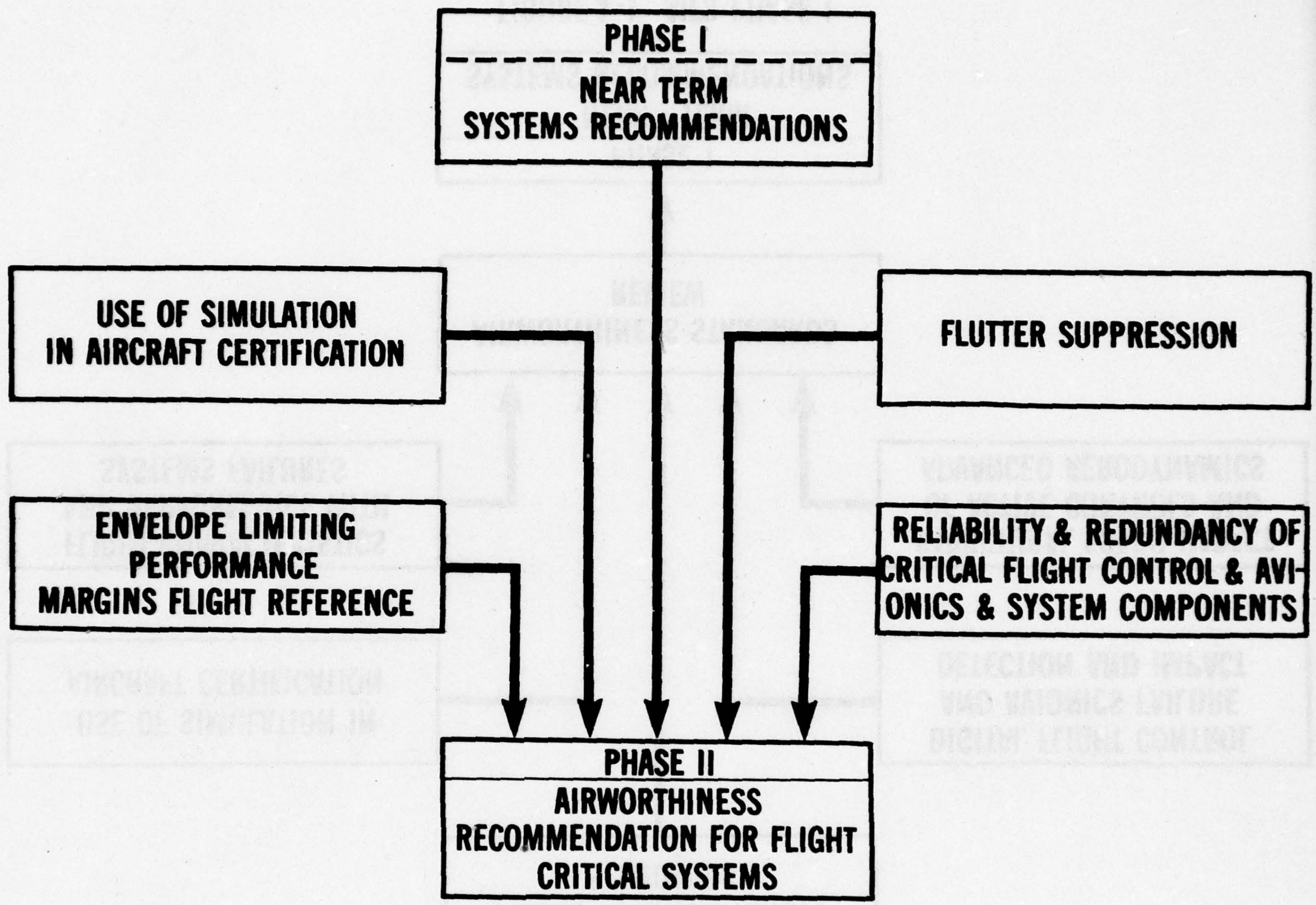


FIGURE 1-2 AIFS PHASE II

In order to meet these technological challenges and to develop the expertise to certify future aeronautical systems, the FAA must advance the airworthiness regulations and develop procedures for application to emerging technologies. Equally as important is evaluation of current regulations and policies which may not accommodate innovative technological advances.

The FAA Flight Standards Service has the regulatory responsibilities of revision and modernization of airworthiness standards and certification procedures to assure the flight safety of new technological innovations. Current standards and procedures address aircraft certification, for the most part, from the concept of separate engineering disciplines. Hydraulic and electrical systems certification, for example, is considered separately from powerplants which is, in turn, separate from structures, and so on. On aircraft incorporating advanced avionics and active controls, the separate technological disciplines will be interdependent and synergistic. Hence, the concept of integrated systems must be applied. Future aircraft may indeed be aptly defined as "Advanced Integrated Flight Systems."

1.1 Objectives

The FAA AIFS Technology Program objectives are to:

1. Evaluate advancing integrated systems technology for impact on FAA.

2. Support the development of certification procedures through data acquisition and analysis and, in the long-term, similarly support airworthiness standards development.

3. Disseminate the resulting technical information within FAA through workshops, symposia, and inputs to training programs.

1.2 Critical Issues and Decisions

The airworthiness considerations which must be addressed include the following:

1. Failure and Modes of Failure

    - Detection of failures.

    - Systems tolerance to failures.

- Degraded performance or characteristics with failure.

- Crew action in the event of failures.

2. Software Validation

- Methods to guarantee fault-free software.

- Measurement procedures for software reliability.

3. Effects of Lightning and Electromagnetic Interference

- Methods to accurately determine and model the effects of lightning and other disturbances on low signal level avionics.

4. Performance, Flight Margins, and Handling Qualities Criteria

- Redefinition of metrics and datum currently used.

5. Structural Criteria

- Reduction of material in the primary aircraft structure.

- Degree of critical dependence upon the electrohydraulic structural mode and maneuver load control systems.

2. PROGRAM MANAGEMENT

The direct management of this program has been established within ARD with the assignment of a full-time program manager and assistant program manager(s). This staff is in ARD-530, the Aircraft Flight Safety Branch.

The scope and complexity of this program requires a structured management concept to assure completeness and continuity in the management process. This process has been developed and is shown in Figure 2-1. This concept involves the use of different planning and working groups as appropriate, and they are described below in detail.

The ARD program manager is responsible for all scheduling, resource planning, and accountability for the program and associated projects.

2.1 AIFS Planning Group

It is the purpose of the AIFS Planning Group to develop the required program tasks. The Planning Group will approve initiation of the tasks and monitor progress of the program. It is staffed by personnel from AFS, AEM, and ARD. The ARD AIFS program manager, ARD-530, is designated as the Chairman of the AIFS Planning Group. ARD is providing a team to support the AIFS Program on a full-time basis. The FAA Flight Simulation Branch at NASA/ARC will provide on-site coordination at NASA/ARC and participate in designated simulation projects that contribute to the accomplishment of this Plan.

Membership of this Group includes representation from the following FAA organizational functions:

- Flight Standards Service
  - Engineering and Manufacturing Division
    - Airframe Branch (AFS-120)
    - Systems Branch (AFS-130)
    - Propulsion Branch (AFS-140)
    - Flight Test Branch (AFS-160)
  - Air Carrier Division
    - Avionics Staff (AFS-206)
  - General Aviation Division
    - Avionics Staff (AFS-804)
- Office of Personnel and Training
  - Training Programs Division
    - Technical Training Branch (APT-310)

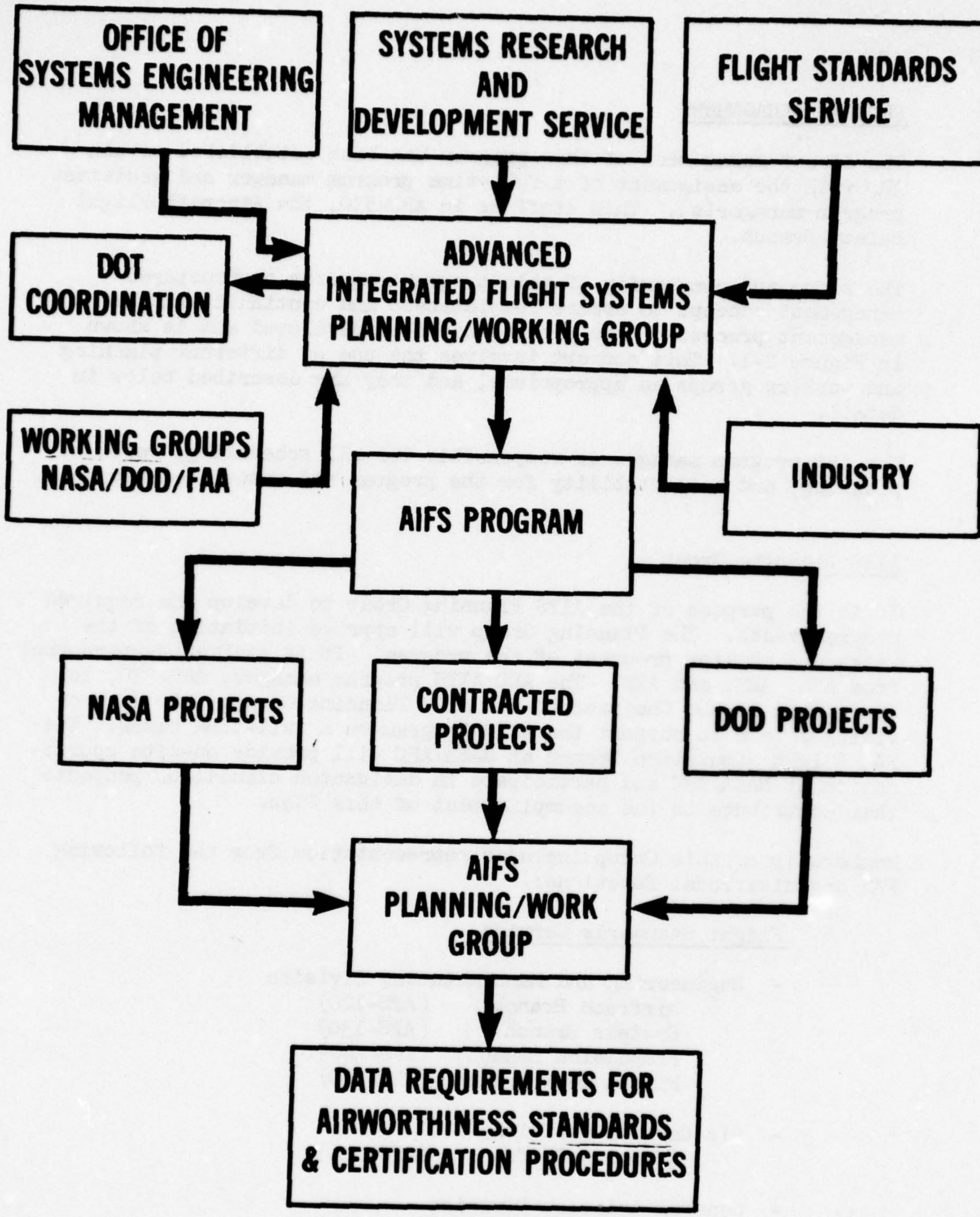


FIGURE 2-1 MANAGEMENT CONCEPTS

- Systems Research and Development Service
  - Aircraft and Noise Abatement Division
    Aircraft Flight Safety Branch (ARD-530)
- Office of Systems Engineering Management
  - Advanced Concepts Staff (AEM-20)

2.2 Interagency Working Group

It is anticipated that the DOT (FAA), NASA, DOD, and other interested Government agencies will form an interagency working group(s) with appropriate membership designated by the parent agencies. The FAA AIFS Planning Group now represents FAA in one such working group with NASA (see Section 2.2.1). The working group(s) will meet regularly to discuss program developments, addition(s) or redirection, progress and status, and to exchange information, data, and final products.

For specific parent agency program interest(s), whereby selected support or task accomplishment is desired, interagency agreements and/or task order agreement(s) will be initiated. These actions will be implemented if they assure mutual benefits and advantages.

2.2.1 FAA/NASA Working Group

By mutual agreement, it has been agreed to establish between the FAA and NASA (regarding integrated flight systems technology for aircraft) an FAA/NASA Working Group on Advanced Integrated Flight Control and Avionic Systems. While a formal agreement has not yet been approved, the Working Group convened informally in March 1977. The Group includes representatives from NASA Headquarters, NASA/LaRC, NASA/ARC, NASA/DFRC, and the previously discussed (Section 2.1) FAA AIFS Planning Group. Interagency coordination since that time, including formal briefings and informal contacts and discussions, have been conducted by members of this Working Group.

2.2.2 Department of Defense

An interagency agreement is not contemplated but, when a Working Group becomes a reality, it is envisioned that an agreement(s) may be consummated. Coordination through the FAA AIFS staff will be initiated with specific facilities or program areas within the DOD.

3. TECHNICAL APPROACH

The task(s) delineated within each project element are efforts which, in the FAA's opinion, need research to meet certification requirements. The research may be accomplished by NASA, DOD, industry, or the FAA. A majority of the information may be acquired by monitoring and close coordination with the performing organization(s) or jointly funded programs based on interagency agreements, but FAA funded contracts will be used when necessary. Table 3.7, Performing Organizations, generally identifies the organization(s) where research is being accomplished and shows that the majority of the work is being accomplished by NASA and DOD. The funding charts (Section 6.0) indicate a minimum level of FAA funding, some of which is transferred to support the needed work in other agencies through interagency agreements.

The major project elements listed below involve various technical disciplines within the FAA organizational structure:

1. Airworthiness Standards and Certification Procedures (3.1).
2. Digital Flight Control and Avionics (3.2).
3. Flight Characteristics and Performance (3.3).
4. Structures (3.4).
5. Propulsion Control (3.5).
6. Crew (3.6).

3.1 Airworthiness Standards and Certification Procedures for AIFS

This project is directed toward the determination, validation, and development (as required) of airworthiness standards and certification procedures for both near-term derivative aircraft and far-term new generation aircraft. In addition to being the lead project by establishing the need for work to be accomplished, this project will be a final product which assimilates the results of AIFS program efforts directed towards the revision of airworthiness standards and certification procedures.

The two projects in this section are related to and in direct support of all other program elements as discussed in Sections 3.2 through 3.6.

These project tasks are being primarily accomplished by FAA (AFS and ARD) with limited funding expended for contract efforts.

3.1.1 Airworthiness Standards/AIFS Technology Considerations

3.1.1.1 Objective

Initiate investigations to determine the need for revision of airworthiness standards for AIFS technology. Consider the effect of existing airworthiness standards on advanced technology accommodation and the corollary impact of advanced technology on airworthiness standards. Where existing airworthiness standards do not exist for implementation of certain energy efficient concepts and/or AIFS technology applications, it will be necessary to develop tentative standards as the technology is applied.

3.1.1.2 Description

Conduct an in-depth analysis of FAR Part 25 (and other appropriate Parts and amendments) to study the advanced technology implications for the stated objectives. This activity will identify those regulations which may be affected by NASA and industry technology development and supporting subcommittee standards and specification development.

1. This activity will include (but not be limited to) an in-house survey of:

   - Near-term activities in progress by NASA and industry as related to AIFS technology.

   - Identity and assessment of the standards and specification efforts of all aircraft and aircraft systems subcommittees.

   - Determination of the relation of aircraft and aircraft systems standards and specifications on airworthiness standards.

2. Initiation of contracted studies to review technological advances and possible regulatory implications.

3. Development of rationale, data, and justification from which the Flight Standards Service can draft proposals for revised standards, special conditions, and certification procedures for AIFS technology.

4. Government/industry workshop(s).

In order to assure that adequate airworthiness standards will exist for implementation of energy efficient concepts and other advanced technology, it may be necessary to consider the development of separate standards. Based on the results of the above tasks, the following may be initiated:

5. Identify specific areas in the FARs which may be deficient and where new criteria or methods of compliance may be necessary.

6. Develop appropriate rationale, data, and justification from which AFS can draft tentative standards, special conditions, and certification procedures as appropriate.

3.1.1.3 Schedule and Milestones

The review of FAR Part 25 will include consideration of the above indicated tasks in accordance with the following:

• NASA and industry near-term activities	March 1978
• Identify FARs which may be deficient	July 1978
• ARINC, RTCA, and SAE Subcommittee's Digital Flight Control and Avionic System Standards and Specifications	July 1978
• SAE-S7 Subcommittee "Flight Characteristics and Performance" Standards	July 1978
• SAE "Structures" Subcommittee Standards and Specifications	July 1978
• SAE "Propulsion" Subcommittee Standards and Specifications	Pending
• Initiate appropriate contract efforts as a follow-on to (1) and in support of (3) above	October 1978
• Initial development of rationale, data, and justification	March 1979
• Develop and provide data for tentative standards	July 1979
• Conduct Government/industry symposium(s)	July 1979

3.1.1.4 End Products

(1) Identification of existing regulations and certification procedures for revision and/or areas requiring new regulations.

(2) Identification of FARs by Part and Sections for those which may be affected.

(3) Background, rationale, and justification for tentative standards for aircraft employing advanced integrated flight systems.

3.2 Digital Flight Control and Avionics

Digital flight control and avionics are the most defined areas with a considerable amount of activity already begun and more planned for the near future. Significant portions of these tasks are being done as a part of the NASA-ACEE/EET/Active Controls, NASA-Ames Digital Flight Controls and Avionics, NASA-Dryden F-8 FBW, NASA-Johnson Space Shuttle, and NASA-Lewis programs. In addition, other important aspects of the effort have begun outside of those programs, including those as delineated by AFFDL (Reference 4) and ASD.

Additional projects may be identified from results of those currently proposed and from the regulatory impact studies of Section 3.1.

3.2.1 Simulation Methods for Advanced Digital Flight Control and Avionic Systems

This NASA-Ames/FAA project is an outgrowth of the digital flight controls and avionics workshop (Reference 3) conducted in April 1976. The specific objectives are to:

1. Investigate the role of real time simulation in the verification of the failure mode and effect analysis for digital flight controls and avionics.

2. Improve acceptance of advanced concepts by identifying the potential of validation processes and simulations.

3. Define the impact of failures, intermittents, faults, errors, etc., in digital systems on safety of flight aspects and the role of the pilot through simulation concepts.

4. Recommend methods and procedures that may be used in validation; i. e., analysis, simulation, flight test, or combinations.

3.2.1.1 Objective

The key objective of this effort is to assess the potential of simulation methods for the validation of failure modes/effects analysis of digital flight control and avionic systems.

3.2.1.2 Description

The content and scope of the project work statement is as follows:

1. Initiate simulation techniques for the evaluation of advanced digital flight control and avionic systems. Document results of simulation experiment(s)/investigation(s), failure(s), and success(es).

2. Assess failure mode/effects on complex electronic hardware and software systems performance. Identify those critical safety of flight failures and investigate generic concepts for analysis and validation.

3. Initiate investigations into industry software systems concepts with special emphasis on methods of documentation, verification, and validation.

4. Conduct appropriate AFS workshops (NASA-Ames and NASA-Dryden) to obtain perspective and assessment of data on industry methods (analytical, simulation, flight).

3.2.1.3 Schedule and Milestones

- Phase I, Study Phase — December 1978

  Define AIFS configuration for simulation.
  Recommend simulation experiments.
  Investigate software concepts.

- Phase II, Review, Assessment, Development, and Validation of Reliability Prediction Software — October 1979

  Review, selection, development, and validation.
  Reliability and failure effects criteria.

- Phase III, Methods for Validation of Flight Software — November 1979

  Review, assess, and describe various validation concepts.

  Describe documentation concepts.

- Phase IV, Conduct Systems/Mission Simulation Investigations — December 1981

  Investigate advanced hardware/software concepts, non-piloted and piloted.

- Industry/Government Workshops — June 1978, December 1979 and 1981

  Methods and rationale workshops (See Section 4.2)

3.2.1.4 End Products

Report on the role and potential of simulation methods for verification and validation of advanced hardware and software concepts.

3.2.2 Redundant Systems Architectural Concepts and Experimental Hardware and Software

To fulfill the needs of safety-critical flight control and avionic systems of future commercial transport aircraft, research efforts are necessary to explore the proposed concepts and designs of candidate computer and software architectures.

This project is a NASA-Langley ongoing effort, with similar military activities at AFFDL.

3.2.2.1 Objective

Investigate, evaluate, classify, and catalog computer and computer system architectural concepts and designs, both those configuration aspects which contribute to reliability and fault tolerance as well as those systems that do not.

3.2.2.2 Description

A comprehensive investigation, classification, and cataloging will be initiated. Full evaluation of all redundant computer and computer system architectural concepts and designs may necessarily require alternative methods developed under other projects of this program. Analytical and simulation methods will be investigated. Where analytical and simulation methods fail to yield required insight into the functional aspects, hardware/software systems may be used.

3.2.2.3 Schedule and Milestones

- Classification of existing triplex and quadruplex digital computer systems — April 1979

- Evaluation and classification of fault-tolerant multiprocessor systems — June 1980

3.2.2.4 End Products

Catalog and report on redundant computer and computer system architectural concepts and designs.

3.2.3 Operating System Software Verification and Validation

The development of advanced digital flight control systems appears imminent. The new technology will facilitate the systems functions being performed by software, which will allow extensive functional changes without hardware changes. The FAA must improve its ability to assess and develop methods and expertise to determine if software is performing its intended functions.

This research is in progress at NASA-Ames (Section 3.2.1), NASA-Langley, and NASA-Dryden, with related projects at AFFDL and ASD.

3.2.3.1 Objective

Acquire an understanding of operating system software concepts and identify and/or develop techniques for verification and validation of software.

3.2.3.2 Description

Investigations will be conducted in the areas of design analysis of digital flight control system software, programing methodology, performance assessment and reliability measurement, software control and documentation. Government and industry flexible software language systems, validation, and test procedures whereby the particular hardware system characteristics can be made semi-transparent yet efficient to the user will be investigated.

3.2.3.3 Schedule and Milestones

• Semi-automated testing and verification of digital flight control system software	April 1979
• Integrated support software system for specification, development testing, documentation, and verification for a wide variety of hardware capabilities and architectures	June 1980

3.2.3.4 End Products

Identify and document the techniques developed for verification and validation of software and the reliability of these techniques.

3.2.4 Fault-Tolerant Software

Fault-tolerant computers are being proposed as the integrated heart of a reliable and maintainable flight control system of the future. Based on candidate computer architectures, fault-tolerant software implementation concepts will be investigated.

NASA-LaRC and NASA-DFRC research programs are the primary contributors for this task.

3.2.4.1 Objective

Investigate the application of logical and physical redundancy design concepts. Explore the recovery block and alternative techniques to both executive and application programs of fault-tolerant flight control computers.

3.2.4.2 Description

Fault-tolerant software development is a parallel special effort (to fault-tolerant hardware development) with special emphasis on advanced software design techniques. A comprehensive investigation of fault-

tolerant software design concepts will be conducted for both executive and application programs. Based on perceived requirements (performance reliability, safety, fault tolerance, economic, maintenance, verification, validation, etc.), define, prove, and evaluate stated capabilities.

3.2.4.3 Schedule and Milestones

• Fault-tolerant software development activities reviewed	July 1978
• Complete feasibility investigations of fault-tolerant software techniques for flight control applications	October 1978
• Performance evaluation of fault-tolerant software applied to experimental systems	April 1980

3.2.4.4 End Products

Report on the fault-tolerant software development feasibility investigation activities and performance evaluation and its reliability.

3.2.5 Functional Assessment Methods

Research is required to develop the capabilities to assess the functional operation of advanced computer and software architecture schemes to fulfill the needs of flight-critical control and avionic system applications. As appropriate, investigate the required tools for evaluating systems specified performance and behavior.

This project is presently an ongoing NASA-LaRC project.

3.2.5.1 Objective

Develop a mathematically based methodology whereby the design of any digital computer or computer system abstractly stated in a formal specification language can be proven to achieve the specification or design intent. Also, develop a diagnostic emulator for analyzing the performance and behavior, in the presence of faults, of hardware and software designs without the need for physical implementation of the hardware.

3.2.5.2 Description

This project will explore and attempt to acquire an understanding of methods developed to prove system designs meet the system functional performance specification.

3.2.5.3 Schedule and Milestones

- Assessment of mathematical design proof methodologies — October 1978
- Review and assessment of diagnostic emulator — October 1981

3.2.5.4 End Products

Document mathematical based methodology and report on development of diagnostic emulator.

3.2.6 Reliability and Safety Assessment Methods

With the advent of fault-tolerant and/or reconfigurable computers (with combinations of hardware/software implementation concepts), the most notable deficiencies of advanced digital flight control and avionic systems are in the field of reliability modeling. Reliability modeling at the present is able to analyze very idealized components and subsystems, with limited modeling concepts and experience in complex integrated systems. Present reliability modeling is based upon simplified assumptions. In considering any fault-tolerant computer and software architecture and avionics, one is faced with the problem of verification and validation of the procedures used for achieving reliability. These procedures may be implemented in either hardware or software, but whichever implementation is used, there is a need to prove that the desired reliability characteristics are achieved.

Significant programs relative to the civil and military needs are in progress at NASA-ARC (Section 3.2.1), NASA-LaRC, NASA-DRFC, and AFFDL.

3.2.6.1 Objective

Initiate an effort to develop advanced reliability assessment and/or diagnostic methods for use in evaluating fault-tolerant and redundant computer flight control systems.

3.2.6.2 Description

Develop advanced reliability assessment modeling techniques and physical simulations for use in evaluating fault-tolerant multimicroprocessor and other redundant computer flight control systems. Develop a probabilistic coverage model for the assessment technique that realistically accounts for the effects of transient faults and software reliability. Determine empirical methods for measuring and estimating coverage values and gather field data on software for the purpose of determining a failure rate comparable to hardware failure rates.

3.2.6.3 Schedule and Milestones

- Transient and coverage model development — October 1978
- Develop equivalent failure rate for software — October 1979
- General computer aided reliability assessment technique — October 1979

3.2.6.4 End Products

Document models, reliability assessment, and diagnostic concepts and methods.

3.2.7 Lightning and Static Discharge Effects

With the advent of low-voltage and current function solid state components and devices which are being used in new generation digital flight control and avionic systems, there are increasing concerns relative to electromagnetic interference effects. The impact of lightning or static discharge effects on flight-critical systems are almost unknown. Earlier vacuum tube electronics and even solid state analog devices were less susceptible to lightning-induced surges. However, solid state microcircuitry is more vunerable to disability or upset due to lightning or other transient effects. The indirect effects have been receiving increased attention as new generation aircraft operation will be dependent on highly complex electronic systems.

With digital flight control and avionics, the indirect effects of lightning or other static discharge sources are likely a hazard to safety of flight. Recognizing this hazard, NASA and the USAF have initiated programs to evaluate the possible electromagnetic effects of lightning on the new generation digital flight control and avionic systems. These activities will analytically and experimentally determine the severity of effects in unprotected systems, thus providing the necessary models, test data, and measurement concepts upon which to base design and airworthiness criteria guidelines for protection of future systems.

A joint NASA-LaRC and FAA project is in progress. NASA-JSC, NASA-LaRC, AFFDL, and industry have conducted and are planning future cooperative activities (with FAA participation). The major airframe organizations have ongoing efforts, with the FAA in coordination with those conducting known research and test programs.

3.2.7.1 Objective

To determine lightning and static discharge effects upon advanced digital flight control and avionic systems.

3.2.7.2 Description

Investigate, characterize, and classify all sources of electrical transients which occur onboard civil transports. Special attention will be given to the characterization and effects of transients upon aircraft electronic systems produced by strong near fields and lightning strikes. From this, methods will be developed with which to challenge fault-tolerant system designs and to specify tests for hardware implementations to determine resistance to all transients. Emphasis will be placed on the development of a transients model for civil transports and techniques for transients immunity.

3.2.7.3 Schedule and Milestones

• Lightning Study Flight Test Program	March 1978
• Based on NASA/USAF Flight Tests and SAE studies, conduct test measurement studies and experimentation	January 1979
• Investigate the indirect effects by analysis, simulation, and flight test on digital flight control and avionic systems	July 1979
• Analyze results of above efforts	January 1980

3.2.7.4 End Products

Document results of flight test programs by reporting the test measurement technique development and the investigations conducted on the "indirect effects" on digital flight control and avionic systems.

3.2.8 Maintenance and Diagnostic Concepts

With future complex integrated digital flight control and avionic systems, maintenance, diagnostic, and operational concepts must be explored for the airlines and FAA. These complex systems must be maintainable by the airlines without appreciable increase in flight control and avionics maintenance costs, which includes consideration of rapid fault or failure isolation and identification in a timely manner. Any concept must identify those systems or components whose failure or out of tolerance conditions, in combination with failures in related or unrelated systems, may preclude safe flight. This equipment should have the capability to accomplish periodic or scheduled maintenance tasks and monitoring of line replaceable unit failure. In order to provide maintenance and component reliability data to the airlines and the FAA, it is desirable that a diagnostic and reporting capability be investigated for possible integration into the total flight or maintenance operation.

Maintainability requirements and concepts as proposed by NASA and the airlines provide the foundation for this effort.

NASA-LaRC research program is the primary contributor for this task.

3.2.8.1 Objective

To initiate research and development of an automatic maintenance aid (AMA) experience data base related to the digital flight control and avionic systems maintenance; and investigate possible maintenance and diagnostic concepts based on aircraft manufacturer, airline, and FAA requirements.

3.2.8.2 Description

Evaluate, analyze, and critique the capabilities of the prototype AMA in the triplex digital flight control computer of the NASA TCV B-737 research aircraft and others. Modify the AMA concept to be fully responsive to needs and requirements as outlined by the civil airlines industry. Specific requirements are:

1. Eliminate unverified removals.
2. Obviate CAT II verification at special centers after maintenance action.
3. Reduce spare inventory.
4. Noninterfering with flight control functions.
5. Designed for low skilled nonelectronic mechanics.
6. No flight crew interface.
7. Self-contained 1-hour detailed maintenance test.
8. Nonpropagating AMA faults.

Based on the results of the NASA AMA efforts and continued interest of advanced maintenance and diagnostic concepts, initiate appropriate studies, development, and an experimentation program.

3.2.8.3 Schedule and Milestones

• Assessment of AMA techniques and capabilities and establishment of impact on civil aviation operations	September 1979

- Modification of AMA concept in response to need and requirements of the civil airline industry — September 1980
- Maintenance, component/system reliability data, and reporting concepts — July 1981

3.2.8.4 End Products

Report on AMA capabilities and other maintenance, component/system reliability data, and reporting concepts.

3.2.9 Economics Assessment Methods

Investigations, studies, and analyses may be initiated to explore the economic impact of advanced digital flight control systems on airline operation when considering regulations, ATC (or other) diversions, dispatch availability (requirement), maintenance, spares, reliability, and so forth.

This project is a NASA-LaRC research activity.

3.2.9.1 Objective

Formulate a model which captures the essential economic factors (departure delay, diversions, etc.) of an airline operation (FAA regulations, company maintenance philosophy) and the operating characteristics (reliability, redundance management strategy, etc.) of new aircraft electronics so as to estimate the airline cost associated with the use of new technology and provide tradeoff data for optimizing engineering designs to the application.

3.2.9.2 Description

Obtain the necessary data and develop a model which may predict the economic impact of various advanced digital flight control system concepts prior to implementation of a proposed design. Estimate the potential savings and select an optimized flight control system. Identify (if significant) the FAA ATC, regulatory, etc., contributions.

3.2.9.3 Schedules and Milestones

- Assessment of preliminary economic model development — April 1979
- Development of flight control system economics evaluation model — April 1980

• Evaluate advanced flight control systems and forecast economic impact	October 1982
• Identify the economic impact of FAA ATC, regulations, etc., contributions	December 1982

3.2.9.4 End Products

Document model and provide a forecast of economic and FAA impact based on advanced technology and designs.

3.3 Flight Characteristics and Performance

Incorporation of advanced systems will provide improved aircraft handling qualities during normal operating modes. However, with system failures or cascading multiple failures, degradations in both handling qualities and performance can occur. Safety implications associated with systems failures suggests consideration of several developmental areas:

1. Determine minimum safe flying qualities; that is, the degraded level at which no further system failures can be tolerated.

2. With progressive failures, determine the amount of degradation of flying qualities which may be accommodated.

3. Identify the failures and combinations of failures which must be demonstrated for FAR compliance.

4. Develop procedures and methods for demonstration of failures.

These and other factors involving flight characteristics form the objective of several handling qualities projects which are listed below:

3.3.1 Minimum Safe Handling Qualities with Cascading System Failures

3.3.1.1 Objective

Support the development of airworthiness criteria related to performance and handling qualities characteristics of future aircraft employing advanced avionics and control technology which considers cascaded system failures.

3.3.1.2 Description

Previous and current stability and control systems have improved handling qualities but have never been the sole provider of stability. Future aircraft may ultimately have an aerodynamically unstable airframe and rely totally on artificial stabilization concepts. The minimum-safe flying qualities which are needed to determine system failure limitations of the ACT systems must be developed and verified.

As part of the NASA EET Program, flying qualities characteristics for certain aircraft employing advanced control technology will be defined. Minimum airworthiness standards to which the characteristics may be compared for safety compliance must be available as a datum. The provision for such a datum or standards is a responsibility of the FAA in its role of assuring a minimum level of safety. It should also be pointed out that NASA-DFRC and AFFDL programs may provide information and data of interest.

The primary problem confronting the incorporation of advanced technology is that there currently exists little or no real-world data on which to base standards development. Confidence in advanced control technology will be gained in the next few years through analytical and simulation techniques, flight test, and nonflight critical fleet application.

The incorporation of wing-tip modification (extensions and/or winglets), reduced static stability, and wing load alleviation systems (maneuver load control, gust alleviation, and/or elastic mode suppression) separately and in concert with each other must be investigated for potential stability and control problems in the presence of failures for the following areas:

- Static Longitudinal Stability.
- Longitudinal Controllability.
- High Speed Characteristics.
- Vibration and Buffet.
- Roll Performance.
- Flutter Margin.

3.3.1.3 Schedule and Milestones

• Baseline data report, application of advanced control concepts	January 1979
• Determination of advanced control concepts safety implications	January 1980

- Generic data to support nonflight critical airworthiness standards — January 1981
- Preliminary establishment of dependability/reliability of flight-critical systems — January 1983
- Data base to support flight-critical airworthiness standards — January 1984

3.3.1.4 End Products

(1) Generic information for development of handling qualities standards for derivative and first generation aircraft employing advanced control concepts.

(2) Handling qualities data in support of standards development for aircraft employing advanced control concepts in a flight dispatch required mode.

3.3.2 Performance Margin Definition

3.3.2.1 Objective

Develop appropriate performance margin criteria for aircraft employing advanced stability and control technology.

3.3.2.2 Description

Since aerodynamic stall speed may no longer be applicable as a basis from which to define performance and safety margins, some other datum such as minimum speeds, maximum sink rate, or other criteria for different operational configurations must be considered. The datum selected must provide for system tolerances, gusts, malfunctions, and the possible increased loads due to system failures.

It is planned that NASA-LaRC, NASA-DFRC, and AFFDL programs may provide significant research data. With that research which may be lacking, the FAA may choose to initiate appropriate research efforts.

3.3.2.3 Schedule and Milestones

- Determination of areas for concern for derivative aircraft — January 1979
- Data to support criteria for derivative aircraft — January 1980

- Determination of flight-critical areas of concern — January 1982
- Data to support flight-critical criteria — January 1983

3.3.2.4 End Products

Generic data and rationale to support development of performance and stability margins criteria applicable to future aircraft employing flight-critical augmentation systems.

3.3.3 Simulation: Validation and Verification (V&V)

3.3.3.1 Objective

Develop the methodologies needed to formulate validation and verification methods for simulations when used as credit for airworthiness compliance.

3.3.3.2 Description

Due to the flight critical nature of high payoff advanced stability and control concepts, simulation may play a strong role in defining the critical flight conditions and failure mode effects. The degree of static and dynamic instabilities which may be tolerated in various modes of flight and failure states will be estimated by pilot-in-loop simulation. The fidelity and degree of realism of the simulated vehicle, ground or in-flight system(s), must be verified and shown to be valid. Part of FAA's handling qualities program will be to develop the validity assessment techniques to properly interpret analytical and simulation presentations.

The techniques, methodologies, and criteria needed to certify simulation for the purpose of showing compliance of handling quality FARs will be developed. Related projects at NASA-DFRC, NASA-ARC, and AFFDL will be reviewed for appropriate information. The FAA will initiate contract efforts to provide information to AFS in support of derivative aircraft implementation (i. e., Lockheed L-1011, Douglas DC-9-80, etc.).

3.3.3.3 Schedule and Milestones

- ARD Study — July 1978
- Validation techniques for simulation methodologies — December 1979
- Flight verification of simulation techniques — October 1980

- Interim criteria, new generation aircraft — January 1981
- Far-term criteria, advanced technology aircraft — January 1983

3.3.3.4 End Products

Validation and verification criteria for simulation methodologies when used in certification of advanced integrated flight systems.

3.3.4 Cockpit and Controller Characteristics

3.3.4.1 Objective

Develop data to support airworthiness standards for cockpit controllers such as side sticks, dual side arm, and other concepts.

3.3.4.2 Description

With the advent of digital avionics, side stick, side arm, and other advanced controllers will become more practical. The artificial feel forces and the human engineering of side stick controls are an important aspect of aircraft handling qualities. Since future aircraft are projected to have aerodynamically unstable airframe designs using fly-by-wire, there will exist no natural aerodynamic feedback of forces, and hence, there will be no natural "feel." Further, pilot commands will be electronic based on a position or force pickup from his cockpit controller. To provide appropriate cues to the pilot and good overall handling qualities for the aircraft, appropriate characteristics must be designed into the controller and the associated feel system. Such characteristics may be similar to conventional stability measures, such as incremental force proportional to airspeed change, or they may include an automatic trim which maintains zero forces in trim. It is important to flight safety to understand the ramifications of controller characteristics. Therefore, studies including simulations of controllers over enlarged flight envelopes are needed. System failure and degradation effects on controller feel forces and displacements need to be investigated.

The FAA, in coordination with NASA-LaRC, NASA-DFRC, and AFFDL, may initiate joint research programs or contract efforts to acquire the needed data.

3.3.4.3 Schedule and Milestones

- System defined — January 1981
- Criteria established — January 1983

3.3.4.4 End Products

Data and background to support recommendations for the establishment of airworthiness criteria for side arm and advanced controllers.

3.4 Structures

The structural aspects of ACT deal mainly with concepts relating to load control. Load control or, more precisely, wing load alleviation (WLA) concepts utilize passive or automatic control functions for the purpose of regulating the net load and load distribution applied to the aircraft structure. WLA includes MLC, GLA, and EMS. FMS might also be included.

The integration of full-time active control systems into the commercial aircraft fleet was initiated with the inclusion of load alleviation yaw damper systems. Far more complex systems are envisioned for future aircraft. All probable loading conditions induced by ACT functions should be investigated including transient loading resulting from systems failure or unscheduled switching between redundant systems.

Near-term ACT functions for derivative airplanes are being considered mainly to avoid or reduce wing structural beef-up which normally accompanies increases in maximum design weights and wing tip extensions. The long-term effort will evaluate the maximum potential of ACT when applied as an integral part of new aircraft design. Such aircraft will rely on active control concepts in flight-critical applications.

Those structures projects currently identified are listed below. Additional projects may be identified from results of those currently proposed and from the regulatory impact studies of Section 3.1.

3.4.1 Wing Load Alleviation

3.4.1.1 Objective

Establish an analytical data base on WLA systems to permit a safety analysis and establish failure modes to be used in design. Evaluate basic WLA systems concepts to ascertain their impact on aircraft structural airworthiness.

3.4.1.2 Description

The incorporation of WLA systems on derivative aircraft will provide for the relief of wing loads associated with maneuvers and turbulence.

Basic WLA system concepts will define the requirements and system configuration for MLC, GLA, and EMS. This project basically relates to work that is now underway at NASA/LaRC and industry contracts as required:

1. NASA/LaRC ACEE/EET funded projects with three major airframe manufacturers, which are presently ongoing, are of primary interest to the FAA. Those efforts will provide the structural data necessary for the analysis of potential benefits and reliability of proposed WLA systems. Specific areas under investigation are:

   - Static-aeroelastic load alleviation analysis.
   - WLA system stability and sensor coupling from maneuvers and structural feedback.
   - Wing elastic modes analysis.
   - Dynamic gust and flutter loads analysis.
   - WLA system reliability and failure analysis.
   - Flight validation.

   It appears that the NASA/LaRC ACEE/EET Program will provide a reasonable data base for determining the structural implications of active control concepts. However, appropriate expanded or additional efforts are necessary to satisfy FAA objectives.

2. A complete power-spectral gust analysis of proposed WLA systems is necessary to assess load reductions due to GLA. Transfer functions for various wing shears, bending moments, and torsions at various wing stations must be determined and correlated with NASA flight test data. In conjunction with this effort, specific techniques must be developed and outlined for the analysis of combined loadings.

3. Fatigue affects of WLA systems on wing life need to be predicted.

Past studies have used bending moments to assess allowable limit strength. This procedure is not sufficiently precise to establish actual limit design stresses since these result from combined loading; therefore, appropriate means of combining and phasing shear, torsion, and bending moment loads should be demonstrated.

3.4.1.3 Schedule and Milestones

NASA

• Flight validation	July 1978
• Static and dynamic loads analysis complete	October 1978
• Failure analysis complete	January 1979

FAA

• Impact on structural criteria determined	December 1979
• Analytical data base established	December 1980

3.4.1.4 End Products

Technical reports which are compilations of generic loads data concerning the effects of basic WLA system concepts on wing structural loading.

3.4.2 WLA System with Wing Tip Modification

3.4.2.1 Objective

Provide a data base on the complete active control WLA and RSS system with wing tip modifications describing the complete systems effectiveness to alleviate and redistribute wing loads. Evaluate the systems impact on aircraft structural airworthiness.

3.4.2.2 Description

All of the theoretical analyses described in Section 3.4.1 will apply here to explore the magnitude of load increase and structural flutter margin decrease experienced due to the wing tip modifications and the potential for load reduction and flutter margin decreases which will be realized by the use of active aileron control. These analyses will provide loads data for critical flight maneuver conditions and flutter critical flight conditions. The amount of aileron control necessary to offset the increase in wing bending moment due to increased span will be determined. Loads for critical maneuver conditions for symmetrical aileron inputs (MLC) to determine effects of a more aft center of

gravity (c. g.) on static and dynamic loads will be evaluated for an aircraft experiencing WLA and RSS system failures to define their interactive effects.

A similar NASA EET Program flight test evaluation as that described in the previous task will be conducted. This flight test will determine the effect WTE and WTW have on maneuver and gust loads. It will further demonstrate the flutter margin reductions for a complete system over the entire flight envelope.

3.4.2.3 Schedule and Milestones

NASA

• Flight evaluation	July 1978
• Static and Dynamic Loads Analysis complete	October 1978
• System Failure Analysis with RSS complete	December 1978

FAA

• Wing Tip Modifications (WTM) implications determined	December 1979
• Criteria established for combined WTM/WLA	July 1980

3.4.2.4 End Products

Technical data reports providing generic loads requirements for high aspect ratio wings with tip modifications utilizing WLA and RSS systems.

3.4.3 Aircraft Structural Loads Criteria based on Aircraft and Atmospheric Dynamics

3.4.3.1 Objective

Evaluate aircraft structural flight loads considering the effects of aircraft stability, control, and handling qualities and the influence of turbulence with the pilot in the loop.

3.4.3.2 Description

An aircraft with augmented stability (AS) may have its flight loads uniquely influenced by the interaction between the pilot and the total

aircraft system. A reevaluation of loads estimation techniques will be performed to develop data on structural flight loads with emphasis on continuous atmospheric turbulence, turbulence penetration speeds, and the effects of aircraft and control system dynamics.

This is an FAA initiated project effort.

3.4.3.3 Schedule and Milestones

- Determine implications — June 1978
- Develop criteria — October 1979

3.4.3.4 End Products

Report on the structural effects of stability and control characteristics and pilot control inputs on maneuver and gust (discrete and PSD) wing and tail loading.

3.5 Propulsion Control

Digital technology provides a feasible means of integrating the propulsion control system with the aircraft flight control syst[illegible] and continuously matching the engine operating point with the aircraft state and flight conditions. Otherwise, unattainable fuel efficiency and health benefits could result. Of course, there is the need for an interdisciplinary combination of conventional fuel system expertise and electronic know-how to support the requirement for extensive use of feedback control technology.

A number of sensor inputs from the air data source and from aircraft state measurements, in addition to sensed measurements of propulsion system state, will have to be appropriately integrated to achieve maximum fuel efficiency and minimum installed drag. In fact, full authority digital electronic control systems may be essential because of the projected wide use of variable geometry and the large number of variables to be controlled in future engines. Control configured aircraft with variable geometry engines will utilize interactive airframe and thrust effects by design, and such effects must be considered from the onset of the synthesis process.

Propulsion Control projects are currently identified below. Additional projects may be identified as advanced propulsion and control studies of NASA and DOD proceed. Studies and demonstrations of propulsion and airframe integration have been proposed at both NASA-DFRC (Propulsion-Flight Control Integration Technology, PROFIT) and at NASA-LeRC. Details of these proposals are not available at this time. Available literature has indicated DOD interest with some closely related studies in progress or completed. The FAA will coordinate/participate and may, (in special cases), initiate contract research studies.

3.5.1 Control Design Approach Studies

3.5.1.1 Objective

Determine the generic approach that is likely for integrated propulsion control from basic engine controls through modifications to the control of current engines to new digital control concepts, to ascertain the effect on airworthiness and safety analysis.

3.5.1.2 Description

The use of automatic engine trimming systems or "flight management systems" on derivatives of current transport aircraft are providing increments of fuel savings and are pointing the way to obtaining better performance from current engines. Such systems have already surpassed the "pilot advisory" stage and are actively and continuously providing precise engine trim. These systems use measurements of various air data and aircraft state parameters which effectively integrate the engine control system with the aircraft control system. As the technology progresses, aircraft systems will be demanding measurements of engine parameters as well since future aircraft design modifications and new designs will be striving for optimum efficiency and optimum propulsive system output. The effects that the engine-airframe interdependence could have on airworthiness and operations such as possible adverse effects on engine operation, required fuel reserves, and changes in engine service life must be investigated and understood.

3.5.1.3 Schedule and Milestones

(1) Determine sensor and signal demands and design concepts for integrated control:

• Current engine control	March 1979
• Modified hybrid control	March 1980
• Digital systems control	September 1981

(2) Evaluate airworthiness impact of integrated control:

- Current engine control — September 1979
- Modified hybrid control — September 1980
- Digital systems control — September 1982

3.5.1.4 End Products

Sufficient generic data base to permit safety analysis and procedures for showing airworthiness impact.

3.5.2 Reliability Analysis Methods for Integrated Propulsion Control

3.5.2.1 Objective

Determine acceptable procedures or approaches for showing the reliability of integrated propulsion control systems when considering the interactive effects with the airframe.

3.5.2.2 Description

New systems which promise improved performance and efficiency will necessarily require a much larger array of reliability considerations. Possibilities for failure and the effects of failures will differ significantly from current single input/single output control methods. Multi-input/multi-output and probably complete computer models which precisely predict the response needed and the inputs required to produce the desired response will characterize engine control systems. Hence, not only must the hardware be analyzed for reliability but also the software. The impact of software which includes extensive engine modeling must be determined through safety analysis. Procedures for performing such an analysis have to be developed. The analysis procedure must consider all elements of the integrated system from "throttle-to-nozzle" and all known or potential inputs to the system.

3.5.2.3 Schedule and Milestones

(1) Identify procedures for integrated propulsion control reliability analysis:

- Monitoring and flight management systems — September 1980
- Fully integrated propulsion/airframe systems — September 1984

3.5.2.4 End Products

Data to support the development and publication of certification guidance material for integrated propulsion control.

3.6 Crew

Investigations to identify the necessary flight safety criteria for utilizing human engineering practices and training principles on advanced integrated flight systems. The necessary research to be done concerning the crew's impact from AIFS will be delineated. Typical subject areas will relate to man-machine compatibility and interfaces, and crew training requirements.

Those crew project(s) currently identified are listed below. Additional projects may be identified from results of those currently proposed and from the regulatory impact studies of Section 3.1.

The FAA may choose to initiate research investigations into those project areas which NASA-ARC, NASA-LaRC, NASA-DFRC, and AFFDL projects do not cover. Close coordination will be effected with those organizations prior to any project initiation.

3.6.1 AIFS Interface with the Total Cockpit

3.6.1.1 Objective

Investigate and determine the flight safety impact of the crew-machine interfaces as related to advanced flight controls and avionic technology.

3.6.1.2 Description

Investigations of the crew interface with aircraft employing advanced flight control and avionic systems technology and advanced cockpit controllers will be conducted. Basic considerations such as pilot/computer input-output interface and pilot/computer decision making loops must be addressed.

A wide body cockpit simulation facility including advanced flight control and avionic systems capabilities would provide the necessary potential for program success.

3.6.1.3 Schedule and Milestones

- FAA in-house study (preliminary) — December 1979
- Define potential cockpit innovations — March 1980

- Guidance material-derivative aircraft — August 1980
- AIFS effect on pilot workload — December 1981
- AIFS integration with display systems — December 1983
- Pilot workload versus degraded flying qualities — January 1984
- Guidance material - new generation aircraft — August 1984

3.6.1.4 End Products

Generic data, criteria, and guidelines which will support crew flight safety concerns in the cockpit of future aircraft.

3.6.2 Crew Training Requirements

3.6.2.1 Objective

Identify training needs for advanced technology aircraft whereby handling characteristics may be different from current fleet stability and control operating modes.

3.6.2.2 Description

Based on the results of the flight characteristics and performance tasks (Section 3.3) and the above (Section 3.6.1) AIFS interface with the total cockpit tasks, identify the need or areas where crew training may be required. Support the development of training criteria related to performance and handling qualities characteristics of future aircraft employing advanced flight controls and avionics technology.

3.6.2.3 Schedule and Milestones

- Determine requirements — March 1984
- Establish training criteria — October 1985
- Final report — January 1986

3.6.2.4 End Products

Generic information criteria and recommendations to support the development of training requirements.

4. TRAINING

Support of training of Flight Standards Service personnel on the AIFS technology is considered a primary program goal. It is not the responsibility of the AIFS Planning Group to initiate or conduct training courses. It is the AIFS Planning Group's responsibility to identify, recommend, and support Flight Standards Service and Office of Personnel and Training relative to potential program workshops and technical training courses.

Program workshops and technical training that is a result of the research conducted in accordance with this planning document may be funded by a variety of sources. These sources may be interagency agreements (with associated contractors), Office of Personnel and Training through the FAA Academy, and other available formal headquarters training budgets and sources. FAA ARD funding is not normally utilized for this purpose. Funding charts in Section 6.0 do not include estimated figures for FAA headquarters funding requirements.

4.1 Flight Standards Service Technical Training

4.1.1 Objective

To recommend and support Flight Standards Service in the initiation and development of formal technical training courses in order to provide timely transfer of generic information and knowledge with advanced technology implementation.

4.1.1.2 Description

It is expected that the AIFS Technology Program will identify products or outcomes for AFS training courses on state-of-the-art, advanced aircraft, and aircraft systems. Through the AIFS Planning Group function, these will be identified to AFS and the Office of Personnel and Training at the earliest possible time to facilitate effective and timely AFS training.

4.1.1.3 Schedule and Milestones

- Establish training needs and outcomes — August 1978
- Preliminary plans development (complete) — May 1979
- Program course(s) implementation (start) — July 1979

4.1.1.4 End Products

Provide inputs, data, and recommendations to AFS for training courses based on Government and industry research and development activities relative to advanced digital flight controls, avionics, and active controls technology efforts.

4.2 Flight Standards Service Workshops and Symposiums

4.2.1 Objective

Establish technology workshops and symposium(s) for Government and industry as a timely and effective medium for information and data transfer and education on key subject areas.

4.2.1.2 Description

Technology workshops established as a result of active interagency agreements, contracts, and associated research and development (R&D) efforts are a timely and effective medium of information transfer. Workshops are selectively planned and recommended by the AIFS Planning Group based on identification of significant requirements for technical education of FAA AFS personnel. The perceived needs and validation of participation in these workshops must be the responsibility of AFS.

A variety of workshops are anticipated as end products from various project elements within this Plan (e. g., Section 3.2, Digital Flight Control and Avionics). As the schedules are refined, AFS will be notified of the workshop subject, detailed description, proposed schedule, length and location of workshop, and level of participation. Subject matter and workshop outlines will be reviewed by AFS and general concurrence obtained prior to finalization and commitment to the workshop. Funding for the workshops may be provided through interagency agreements/contracts, or the designated training budget.

Symposia are proposed which will provide a timely transfer of research information and data. NASA/FAA are proposing to conduct symposia or national forums which will report on status, progress, and program results to date of NASA, DOD, FAA, and industry research. Key subject areas where consideration will be given include analysis, simulation, and flight methods for validation and failure effects analysis, reliability assessment, software validation, flight characteristics and performance, etc.

4.2.1.3 Schedule and Milestones

• Preliminary identification of workshops/ symposia	September 1977
• NASA/DFRC Workshop	June 1978

- NASA/ARC Workshop(s) - Phase I — Fall 1978
- NASA/FAA Symposium for Industry/Government — Summer 1979
- NASA/ARC - FAA Workshops (Phase IV Simulation Methods
  - CTOL Contractor — Early 1980
  - Helicopter — Early 1981
- NASA/LaRC Workshop(s) — TBD

4.2.1.4 End Products

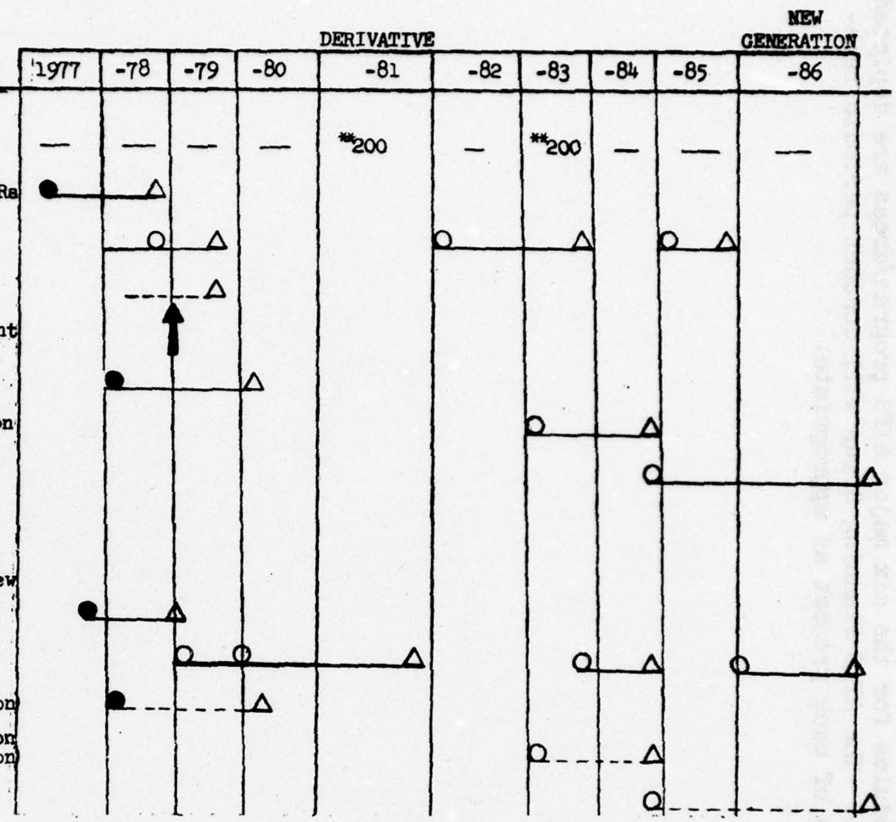
Research information and data transfer and technical education of Government (FAA and NASA) technical personnel.

5. SCHEDULE/MILESTONES/FUNDING

Proposed schedules for the six major AIFS program/areas are depicted in Figure 5-1. The AIFS Planning Group will conduct periodic technical reviews of each project as appropriate.

*SCHEDULE/MILESTONES/FUNDING

3.1 AIRWORTHINESS STANDARDS AND CERTIFICATION PROCEDURES



3.1.1 Airworthiness Standards/AIFS Technology Considerations

- Conduct In-House Survey of FARs
- Contract Studies
- Rationale, Data, etc.
- Workshop(s)-Industry/Government
- Interim Report - Derivative
- Interim Report - New Generation
- Final Report

- Identify: FAR Deficiencies, New Criteria, and Methods for Compliance
- Contract Studies
- Interim Report - Derivative (Rationale, Data, Justification)
- Interim Report - New Generation (Rationale, Data, Justification)
- Final Report

*SCHEDULE/MILESTONES LEGEND

LEGEND	START	COMPLETE	EVENT
PLANNED	○	△	↑
ACTUAL	●	▲	↓

** FUNDING

FIGURE 5-1

SCHEDULE/MILESTONES/FUNDING

3.2 DIGITAL FLIGHT CONTROL AND AVIONICS

					DERIVATIVE					NEW GENERATION
	1977	-78	-79	-80	-81	-82	-83	-84	-85	-86
3.2.1 Simulation Methods for Advanced Digital Flight Control and Avionic Systems	75	75	75	75	75	75	-	-	-	-
• Phase I, Study Phase, AIFS Configuration										
• Phase II, Investigate/Validation Reliability Prediction Software										
• Phase III, Validation of Flight Software										
• Phase IV, Systems/Mission Simulations (CTOL and Helicopter Systems)										
• Government/Industry Workshops										
• Final Report(s)										
3.2.2 Redundant Systems Architectural Concepts and Experimental Hardware/Software	-	-	15	25	-	-	-	-	-	-
• Investigate Computer Concepts/Designs and Classify										
• Evaluate Concepts and Designs and Classify										
• Analytical/Simulation Methods Investigations										
• Interim Report										
• Final Report										

SCHEDULE/MILESTONES/FUNDING

3.2 DIGITAL FLIGHT CONTROL AND AVIONICS (CONTINUED)

					DERIVATIVE					NEW GENERATION
	1977	-78	-79	-80	-81	-82	-83	-84	-85	-86
3.2.3 Operating System Software Verification and Validation	-	-	25	45	-	-	-	-	-	-
• Define Industry Hardware/Software Implementation Concepts										
• Software Verification/Validation Methods										
• Workshops										
• Interim Report										
• Final Report										
3.2.4 Fault Tolerant Software	-	-	-	-	-	-	-	-	-	-
• Investigate Software Design Review										
• Define Software Techniques for Flight Control										
• Performance Evaluation of Software										
• Interim Report										
• Final Report										
3.2.5 Functional Assessment Methods	-	25	25	30	60	-	25	25	25	25
• Develop Advanced Methodologies for Proof of Design										

SCHEDULE/MILESTONES/FUNDING

3.2 DIGITAL FLIGHT CONTROL AND AVIONICS (CONTINUED)

	1977	-78	-79	-80	-81	-82	-83	-84	-85	-86
					DERIVATIVE					NEW GENERATION
3.2.5 Functional Assessment Methods - CONTINUED										
• Develop Diagnostic Tools for Performance Analysis										
• Interim Report										
• Final Report										
3.2.6 Reliability and Safety Assessment Methods	-	-	-	25	45	-	-	-	-	-
• Transient/Coverage Model Development										
• Investigate Failure Data for Software										
• Computer Aided Reliability Assessment Technique										
• Workshop										
• Interim Report										
• Final Report										
3.2.7 Lightning and Static Discharge Effects	75	75	75	75	75	75	50	25	-	-
• Lightning Study Flight Test Program										
• Conduct Test Measurement and Experimentation Studies										

SCHEDULE/MILESTONES/FUNDING

3.2 DIGITAL FLIGHT CONTROL AND AVIONICS (CONTINUED)

	1977	-78	-79	-80	-81	-82	-83	-84	-85	-86
					DERIVATIVE					NEW GENERATION
3.2.7 Lightning and Static Discharge Effects - CONTINUED										
• Investigate Indirect Effects on Digital Avionic Systems										
• Workshop(s)										
• Interim Report										
• Final Report										
3.2.8 Maintenance and Diagnostic Concepts	-	-	-	25	25	25	-	25	-	-
• Evaluate/Analyze AMA Concept										
• Modify and Test AMA Concept										
• Maintenance, Reliability, and Reporting Concepts										
• Workshop										
• Interim Report										
• Final Report										
3.2.9 Economics Assessment Methods	-	-	-	-	20	25	25	25	10	10
• Assessment of Economic Models										
• Develop Flight Control Economics Evaluation Model										
• Evaluate Advanced Systems Economic Impact										

SCHEDULE/MILESTONES/FUNDING

3.2 DIGITAL FLIGHT CONTROL AND AVIONICS (CONTINUED)

	1977	-78	-79	-80	-81	-82	-83	-84	-85	-86
					DERIVATIVE					NEW GENERATION
3.2.9 Economic Assessment Methods - CONTINUED										
• Identify Impact of FAA Contributions						△				
• Interim Report(s)					△					
• Final Report								△		

SCHEDULE/MILESTONES/FUNDING

3.3 FLIGHT CHARACTERISTICS AND PERFORMANCE

	DERIVATIVE									NEW GENERATION
	1977	-78	-79	-80	-81	-82	-83	-84	-85	-86
3.3.1 Minimum Safe Handling Qualities for Cascading System Failures	-	100	-	-	-	50	100	50	-	-
- Determine Derivative Impact on Stability, Controllability, Performance, etc.										
- Resolve Problem Areas identified in Derivative Certification										
- Determine New Generation Aircraft Flight Critical Concerns on Stability, Controllability, Performance, etc.										
• Interim Report(s)										
- Safety Implications.										
- Preliminary Establishment of Cascading System Failure Effects.										
• Final Report(s)										
- Generic Data										
• Non-Flight Critical										
• Flight Critical										

SCHEDULE/MILESTONES/FUNDING

3.3 FLIGHT CHARACTERISTICS AND PERFORMANCE (CONTINUED)

	1977	-78	-79	-80	-81	-82	-83	-84	-85	-86
					DERIVATIVE					NEW GENERATION
3.3.2 Performance Margin Definition	-	-	100	-	-	-	50	-	-	-
- Determine Advanced Technology Impact on Performance and Safety Margins (i. e., Stall Speed).				○	△					
- Establish New Criteria and Datums.						○	△			
• Interim Reports										
- Determination of Areas of Concern.			○	△						
- Preliminary Identification of Criteria/Datums.					○	△				
• Final Report							○ △			
3.3.3 Simulation: Verification and Validation	-	-	100	100	-	-	-	-	-	-
- Simulation Techniques			○	△						
- Flight Verification of Simulator			○		△					

SCHEDULE/MILESTONES/FUNDING

3.3 FLIGHT CHARACTERISTICS AND PERFORMANCE (CONTINUED)

	1977	-78	-79	-80	-81 (DERIVATIVE)	-82	-83	-84	-85	-86 (NEW GENERATION)
3.3.3 Simulation: Verification and Validation (CONTINUED)										
• Interim Report(s)				○—△						
• Final Report					○—△					
3.3.4 Cockpit and Controller Characteristics	-	-	-	-	-	50	50	50	-	-
- Define Systems (i. e., Side-Stick, Dual Side-Arm, etc.) and Implications.					○—	—△				
- Develop Criteria.						○—	—△			
• Interim Report					○—	—△				
• Final Report							○—△			

SCHEDULE/MILESTONES/FUNDING

3.4 STRUCTURES

	1977	-78	-79	-80	-81	-82	-83	-84	-85	-86
	DERIVATIVE									NEW GENERATION
3.4.1 Wing Load Alleviation										
• Determine Impact on Structural Criteria			○	△						
• Establish Analytical Data Base			○		△					
• Interim Reports										
- Preliminary Analysis.		○ △								
- Impact on Structural Criteria.		○	△							
• Final Report				○	△					
3.4.2 WLA System with Wing Tip Modification										
- Determine Wing Tip Modification Implications.			○	△						
- Establish criteria for combine Wing Load Alleviation System/ Wing Tip Modification			○	△						
• Interim Report				○ △						
• Final Report				○	△					

3.4 STRUCTURES (CONTINUED)

SCHEDULE/MILESTONES/FUNDING

	1977	-78	-79	-80	-81	-82	-83	-84	-85	-86
					DERIVATIVE					NEW GENERATION
3.4.3 Aircraft Structural Loads Criteria based on Aircraft and Atmospheric Dynamics	120	120	-	-	-	-	-	-	-	-
• Determine Implications										
• Develop Criteria										
• Final Report										

SCHEDULE/MILESTONES/FUNDING

3.5 PROPULSION CONTROL

	DERIVATIVE									NEW GENERATION
	1977	-78	-79	-80	-81	-82	-83	-84	-85	-86
3.5.1 Control Design Approach Studies	-	-	-	200	-	150	150	-	-	-
• Identify Control Design Approach Sensor Signal Demands and Design Concepts		○			△					
• Determine Airworthiness Impact			○			△				
• Interim Report(s)										
• Final Report(s)										
3.5.2 Reliability Analysis Methods for Integrated Propulsion Control										
• Monitoring and Flight Management				○	△					
• Fully Integrated Propulsion/ Airframe Systems						○		△		
• Interim Report(s)										
• Final Report(s)										

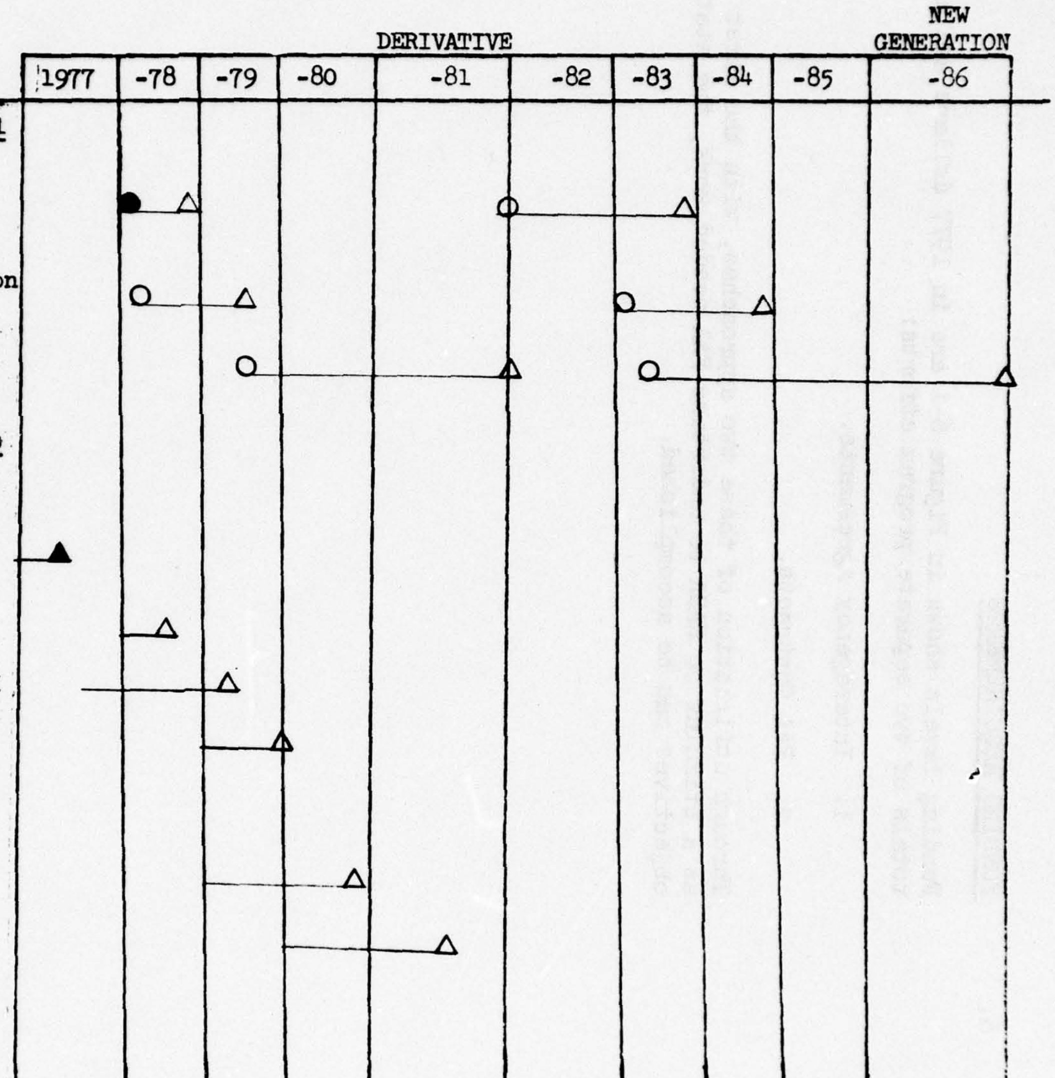
SCHEDULE/MILESTONES/FUNDING

3.6 CREW

		1977	-78	-79	-80	-81	-82	-83	-84	-85	-86
		DERIVATIVE									NEW GENERATION
3.6.1	AIFS Interface with the Total Cockpit	-	-	-	200	-	150	150	-	-	-
	• Derivative Aircraft Cockpit Innovations										
	• Degree of Avionics Integration										
	• Pilot Information Requirements from AIFS										
	• AIFS Effect on Pilot Workload										
	• AIFS Information and Warning Output										
	• Integration of AIFS with Other Information and Command Display Systems										
	• Pilot Workload with Degraded Flying Qualities										
3.6.2	Crew Training Requirements	-	-	-	-	-	-	-	-	-	-
	- Determine Requirements										
	- Establish Training Criteria										
	• Final Report										

SCHEDULE/MILESTONES/FUNDING

4. TRAINING



4.1 **Flight Standards Service Technical Training**

- Establish Training Needs and Outcomes
- Preliminary Plans (Coordination with AFS/APT/AAC)
- Program Implemented (AFS/AAC)

4.2 **Flight Standards Service Workshops and Symposiums**

- Preliminary Identification of Workshops and Government/ Industry Symposium
- NASA/DFRC Workshop
- NASA/ARC Workshop(s) - Phase I
- NASA/FAA Symposium
- NASA/ARC-FAA Workshops - Phase IV
  - CTOL
  - Helicopter

NOTE: NOT ARD FUNDS
(FUNDING TO BE DETERMINED)

6. FUNDING REQUIREMENTS

Funding levels shown in Figure 6-1 are in 1977 dollars and are the totals of two separate program efforts:

1. Interagency Agreements.

2. FAA Contracts.

Through utilization of these two approaches, with the first intended as a stimulus to NASA to undertake FAA needed work, the stated objectives can be accomplished.

FUNDING

(1977 K DOLLARS)

PROJECT/FISCAL YEAR	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
ARD CONTRACT DOLLARS*										
• Airworthiness Studies	--	-	-	-	200	-	200	-	-	-
• Digital Flight Control	150	175	215	300	300	200	100	100	35	35
• Flight Characteristics	-	100	200	100	-	100	200	100	-	-
• Structures	120	120	-	-	80	-	-	-	-	-
• Propulsion	-	-	-	100	-	150	150	-	-	-
• Crew	-	-	-	200	-	150	150	-	-	-
• Training**	-	-	-	-	-	-	-	-	-	-
	270	395	415	700	580	600	800	200	35	35
NAFEC CONTRACT DOLLARS	-	-	-	-	50	50	50	50	50	50
TOTAL DOLLARS	270	395	415	700	630	650	850	250	85	85

*FUNDING ESTIMATED AS: 45% Interagency Agreements; 55% ARD Contracts (and other)

**NOT ARD FUNDS

FIGURE 6-1

7. RESOURCE REQUIREMENTS

The resources estimated in Figure 7-1 identify the necessary anticipated in-house expenditures for the completion of the AIFS program.

*MANPOWER (ARD/NAFEC)
(1977 K DOLLARS)

PROJECT/FISCAL YEAR	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
• Airworthiness Standards	25	25	25	25	25	25	25	25	20	20
• Digital Flight Control	35	35	50	50	50	50	50	50	30	30
• Flight Characteristics	25	25	30	30	30	25	25	25	20	20
• Structures	15	15	20	15	10	10	10	10	5	5
• Propulsion	5	5	10	15	15	20	20	20	15	15
• Crew	10	10	20	20	25	20	20	30	20	20
• Training (ARD Support Only)	5	5	5	5	5	10	10	10	10	10
TOTAL DOLLARS	120	120	160	160	160	160	160	160	120	120

*Based on 40 K Dollars per Man-Year

FIGURE 7-1

REFERENCES

1. NASA/OAST "Aircraft Fuel Conservation Technology," Task Force Report, dated September 10, 1975

2. FAA/ARD-530 Staff Study, "Review of Active Control Technology," Letter Report RD-76-11-LR, dated December 1976

3. NASA TMX-73, 174 "Government/Industry Workshop on Methods for the Certification of Digital Flight Controls and Avionics," NASA Technical Memorandum, dated October 1976

4. Air Force Flight Dynamic Laboratory, "Digital Flight Control Technology Roadmap," Report AFFDL/FGL-TM-73-65, dated January 1977 (Revision D)

APPENDIX A

GLOSSARY OF ACRONYMS

ACEE	-	Aircraft Energy Efficiency
ACT	-	Active Control Technology
AEM	-	Office of Systems Engineering Management
AFFDL	-	Air Force Flight Dynamics Laboratory
AFS	-	Flight Standards Service
AIFS	-	Advanced Integrated Flight Systems
AMA	-	Automatic Maintenance Aid
ARD	-	Systems Research and Development Service
ARINC	-	Aeronautical Radio, Incorporated
AS	-	Augmented Stability
ASD	-	Aeronautical Systems Division
ATC	-	Air Traffic Control
CAT	-	Category
CCV	-	Control Configured Vehicle
CFR	-	Code of Federal Regulations
C. G.	-	Center of Gravity
CTOL	-	Conventional Takeoff and Landing
DOD	-	Department of Defense
DOT	-	Department of Transportation
EET	-	Energy Efficient Transport
EL	-	Envelope Limiting
EMS	-	Elastic Mode Suppression
FAA	-	Federal Aviation Administration
FAR	-	Federal Aviation Regulations
FBW	-	Fly-By-Wire

FMC	Flutter Mode Control
GLA	Gust Load Alleviation
MLC	Maneuver Load Control
NAFEC	National Aviation Facilities Experimental Center
NASA	National Aeronautics and Space Administration
NASA/ARC	NASA/Ames Research Center
NASA/DFRC	NASA/Dryden Flight Research Center
NASA/JSC	NASA/Johnson Space Center
NASA/LaRC	NASA/Langley Research Center
NASA/LeRC	NASA/Lewis Research Center
PSD	Power Spectral Density
RSS	Reduced (Relaxed) Static Stability
RTCA	Radio Technical Commission for Aeronautics
SAE	Society of Automobile Engineers
TBD	To Be Determined
TCV	Terminal Configured Vehicle
USA	United States Army
USAF	United States Air Force
USN	United States Navy
WLA	Wing Load Alleviation
WTE	Wing Tip Extension
WTW	Wing Tip Winglets

APPENDIX B

TABLE 3.7 PERFORMING ORGANIZATION(S)

AIFS PROJECTS

TABLE 3.7 PERFORMING ORGANIZATION(S)

(REFERENCED SECTIONS) AIPS PROJECTS

(REFERENCED SECTIONS) AIPS PROJECTS	PERFORMING ORGANIZATION										
	FAA				NASA				DOD		OTHER
	AFS	AEM	ARD	NAFEC	ARC	LaRC	DFRC	LeRC	AFFDL/ WPAFB	ASD/ WPAFB	
3.1 Airworthiness Standards and Certification Procedures											
3.1.1 Airworthiness Standards/AIPS Technology Considerations											
1. Conduct In-House Survey Appropriate FAR Parts	X		X								
2. Initiate Contracted Studies			X								
3. Develop Rationale, Data, and Justification	X		X								
4. Industry/Government Workshop	X		X								
5. Identify FAR Deficiencies, New Criteria, and Methods of Compliance	X		X								
6. Develop Rationale, Data, and Justification for Tentative Standards	X										

NOTE:

C = Coordination
IA = Interagency Agreement
FF = Full Funded/(FAA, NASA, USAF)
PP = Partial Funded/(FAA, NASA, USAF)

AIFS PROJECTS	PERFORMING ORGANIZATION										
	FAA				NASA				DOD		OTHER
	AFS	AEM	ARD	NAFEC	ARC	LaRC	DFRC	LeRC	AFFDL/ WPAFB	ASD/ WPAFB	
3.2 Digital Flight Control and Avionics											
3.2.1 Simulation Methods for Advanced Digital Flight Control and Avionic Systems											PF/NASA PF/FAA } IA
1. Define AIFS Configuration, Recommend Simulation Experiments, and Investigate Software Concepts					X						
2. Review, Assessment, Development, and Validation of Reliability Prediction Software					X						
3. Methods for Validation of Flight Software					X						
4. Conduct Systems/Mission Simulation Investigations					X						
5. Conduct Technical Workshops on Industry Methods and Rationale			X		X						
3.2.2 Redundant Systems Architectural Concepts and Experimental Hardware and Software						X			X		
1. Investigate, Classify, and Catalog Computer Concepts and Designs											
2. Evaluate Concepts and Designs											
3. Analytical and Simulation Methods will be investigated											

AIPS PROJECTS	FAA				NASA				DOD		OTHER
	AFS	AEM	ARD	NAFEC	ARC	LaRC	DFRC	LeRC	AFFDL/ WPAFB	ASD/ WPAFB	NASA/ JSC
3.2.3 <u>Operating System Software Verification and Validation</u>					X	X	X		X	X	
1. Define Industry Hardware and Software Implementation Concepts											
2. Identify and Develop Methods and Techniques for Software Verification and Validation											
3.2.4 <u>Fault Tolerant Software</u>						X	X				
1. Investigate Software Design Concepts											
2. Define, Prove, and Evaluate Stated Capabilities											
3.2.5 <u>Functional Assessment Methods</u>						X					
1. Develop Advanced Methodologies for Proof of Design											
2. Develop Diagnostic Tools for Performance Analysis											
3.2.6 <u>Reliability and Safety Assessment Methods</u>					X	X	X		X		PF/NASA/ARC
1. Develop Advanced Reliability Models											
2. Computer Aided Reliability Assessment Techniques											

Performing organization groups: FAA, NASA, DOD, OTHER, under the heading PERFORMING ORGANIZATION.

AIPS PROJECTS

AIPS PROJECTS	FAA				NASA				DOD		OTHER
	AFS	AEM	ARD	NAFEC	ARC	LaRC	DFRC	LeRC	AFFDL/ WPAFB	ASD/ WPAFB	NASA/ JSC
3.2.7 Lightning and Static Discharge Effects			X			X			X		PF/FAA X } IA-NASA
1. Lightning Study Flight Test											
2. Conduct Measurement Study and Experimentation											
3. Investigate Effects on Digital Flight Control and Avionics											
4. Assess Adequacy of SAE Proposal and Recommend Guidance Material											
5. Workshop(s)											
3.2.8 Maintenance and Diagnostic Concepts						X					
1. Evaluate and Analyze Capabilities of NASA AMA Concept											
2. Initiate Studies, Development, and Experimentation in Advanced Concepts											
3.2.9 Economics Assessment Methods						X					
1. Obtain Data and Develop Prediction Model											
2. Estimate Potential Savings and Select a Design											

AIFS PROJECTS	FAA				NASA				DOD		OTHER
	AFS	AEM	ARD	NAFEC	ARC	LaRC	DFRC	LeRC	AFFDL/ WPAFB	ASD/ WPAFB	
3.3 Flight Characteristics and Performance											
3.3.1 Minimum Safe Handling Qualities for Cascading Failures											
1. Determine Derivative Impact on Stability, Controllability, Performance, etc.			X			X	X		X		
2. Resolve Problem Areas identified in Derivative Aircraft Certification	X		X								
3. Determine New Generation Aircraft Flight Critical Concerns		X	X			X	X		X		
3.3.2 Performance Margin Definition											
1. Determine Impact on Performance and Safety Margins (i. e., Stall Speed, etc.)			X			X	X		X		
2. Establish New Criteria and Datums	X		X								
3.3.3 Simulation; Validation and Verification (V&V)											
1. Validation Techniques for Simulators			X								
2. Flight Verification of Simulators			X		X	X			X		
3. Interim Criteria - New Generation Aircraft	X		X								
4. Far-Term Criteria - Advanced Technology	X		X								

AIFS PROJECTS

	PERFORMING ORGANIZATION										
	FAA				NASA				DOD		OTHER
	AFS	AEM	ARD	NAFEC	ARC	LaRC	DFRC	LeRC	AFFDL/ WPAFB	ASD/ WPAFB	
3.3.4 Cockpit and Controller Characteristics											
1. Define Systems (Side-Stick, etc.) and the Implications		X	X			X			X		
2. Develop Criteria			X			X	X		X		

AIFS PROJECTS	FAA				NASA				DOD		OTHER
	AFS	AEM	ARD	NAFEC	ARC	LaRC	DFRC	LeRC	AFFDL/ WPAFB	ASD/ WPAFB	
3.4 Structures											
3.4.1 Wing Load Alleviation			X			X			X		
1. Determine Impact on Structural Criteria											
2. Establish Analytical Data Base											
3.4.2 WLA System with Wing Tip Modifications			X			X					
1. Determine Wing Tip Modification Implications											
2. Determine Combine Wing Load Alleviation System/ Wing Tip Modification Implications											
3.4.3 Aircraft Structural Loads Criteria based on Aircraft and Atmospheric Dynamics			X								
1. Determine Implications											
2. Develop Criteria											

Performing Organization

AIFS PROJECTS	FAA				NASA				DOD		OTHER
	AFS	AEM	ARD	NAFEC	ARC	LaRC	DFRC	LeRC	AFFDL/ WPAFB	ASD/ WPAFB	
3.5 <u>Propulsion Control</u>											
3.5.1 <u>Control Design Approach</u>											
1. Identify Sensor and Signal Demands and Design Concepts			X				X	X	X		
2. Determine Airworthiness Impact of Integrated Control	X		X								
3.5.2 <u>Reliability Analysis Methods</u>			X				X	X	X		
1. Monitoring and Flight Management											
2. Fully Integrated Propulsion/Airframe Systems											

Table header: PERFORMING ORGANIZATION

AIFS PROJECTS

	PERFORMING ORGANIZATION										
	FAA				NASA				DOD		OTHER
	AFS	AEM	ARD	NAFEC	ARC	LaRC	DFRC	LeRC	AFFDL/ WPAFB	ASD/ WPAFB	
3.6 Crew (Preliminary Scope)											
3.6.1 AIFS Interface with the Total Cockpit			X			X			X		
1. Derivative Aircraft Innovations		X									
2. Degree of Avionics Integration		X			X						
3. Pilot Information Requirements	X	X			X						
4. AIFS Effect on Pilot Workload	X				X		X				
5. Information/Warning Output	X				X		X				
6. System Integration		X			X						
7. Flying Qualities Degradation Effects					X		X				
3.6.2 Crew Training Requirements	X		X								
1. Determine Requirements					X	X	X		X		
2. Establish Training Criteria											

AIPS PROJECTS	PERFORMING ORGANIZATION										
	FAA				NASA				DOD		OTHER
	AFS	AEM	ARD	NAFEC	ARC	LaRC	DFRC	LeRC	AFFDL/ WPAFB	ASD/ WPAFB	
4. Training	X										
4.1 Flight Standards Service Technical Training											
4.2 Flight Standards Service Workshops and Symposiums			X		X	X	X				